Linking future Gulf Stream warming and increased European winter precipitation in eddy-rich global models

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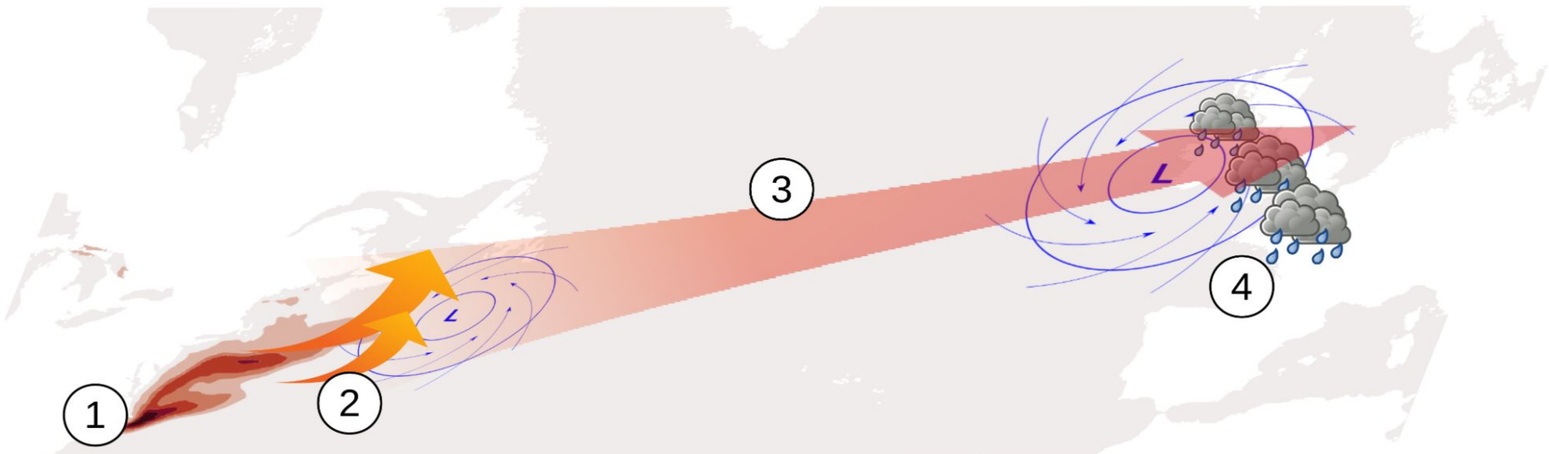
Different future changes in the Gulf Stream in the eddy-rich global model HadGEM3-GC31 with consequences for European precipitation



Schematic of the chain of events linking the Gulf Stream warming **(1)** and the precipitation increase over Europe **(4)** in the eddy-rich global model HadGEM3-GC3.1. A northward shift and strong local warming of the Gulf Stream destabilizes the atmosphere and favors the formation of winter extratropical cyclones **(2)**. These continue to grow over the North Atlantic **(3)**, aided by intensified diabatic heating and upper-troposphere jet, and eventually bring more rainfall to NW Europe.

Projected changes, especially in the Gulf Stream, are different at lower resolutions. Does this also happen for other models?

HadGEM3-GC31 model version

HH
~50 km atmosphere
~8 km ocean
1 historical simulation
1 SSP5-8.5 scenario
*Stippling on plots: anomalies outside the range of projected changes at all lower resolutions

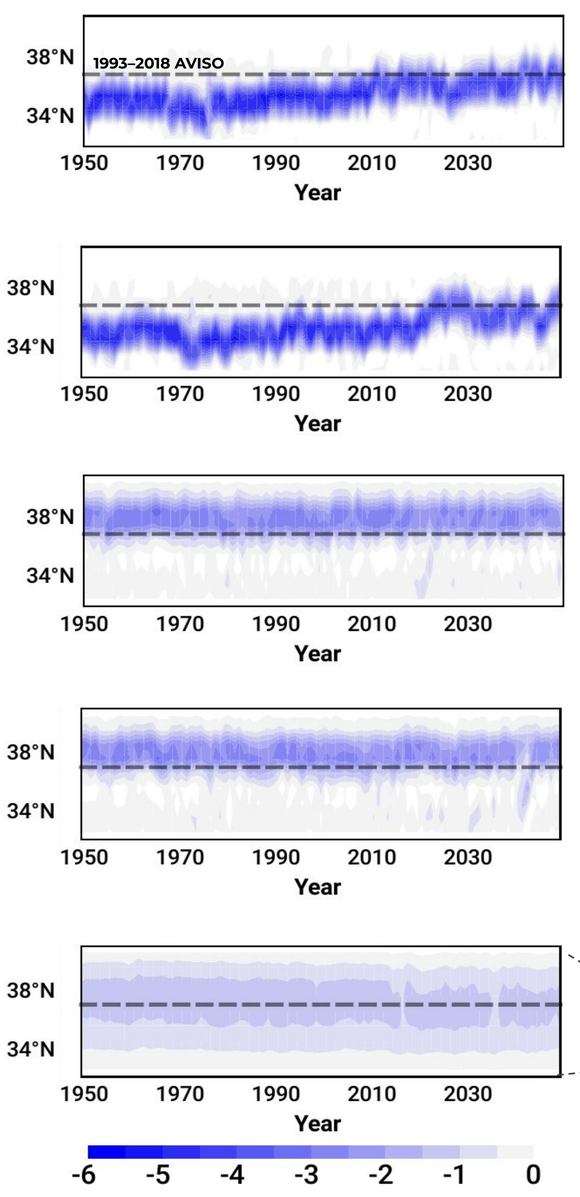
MH
~100 km atmosphere
~8 km ocean
1 historical simulation
1 SSP5-8.5 scenario

HM
~50 km atmosphere
~25 km ocean
3 historical simulations
3 SSP5-8.5 scenarios

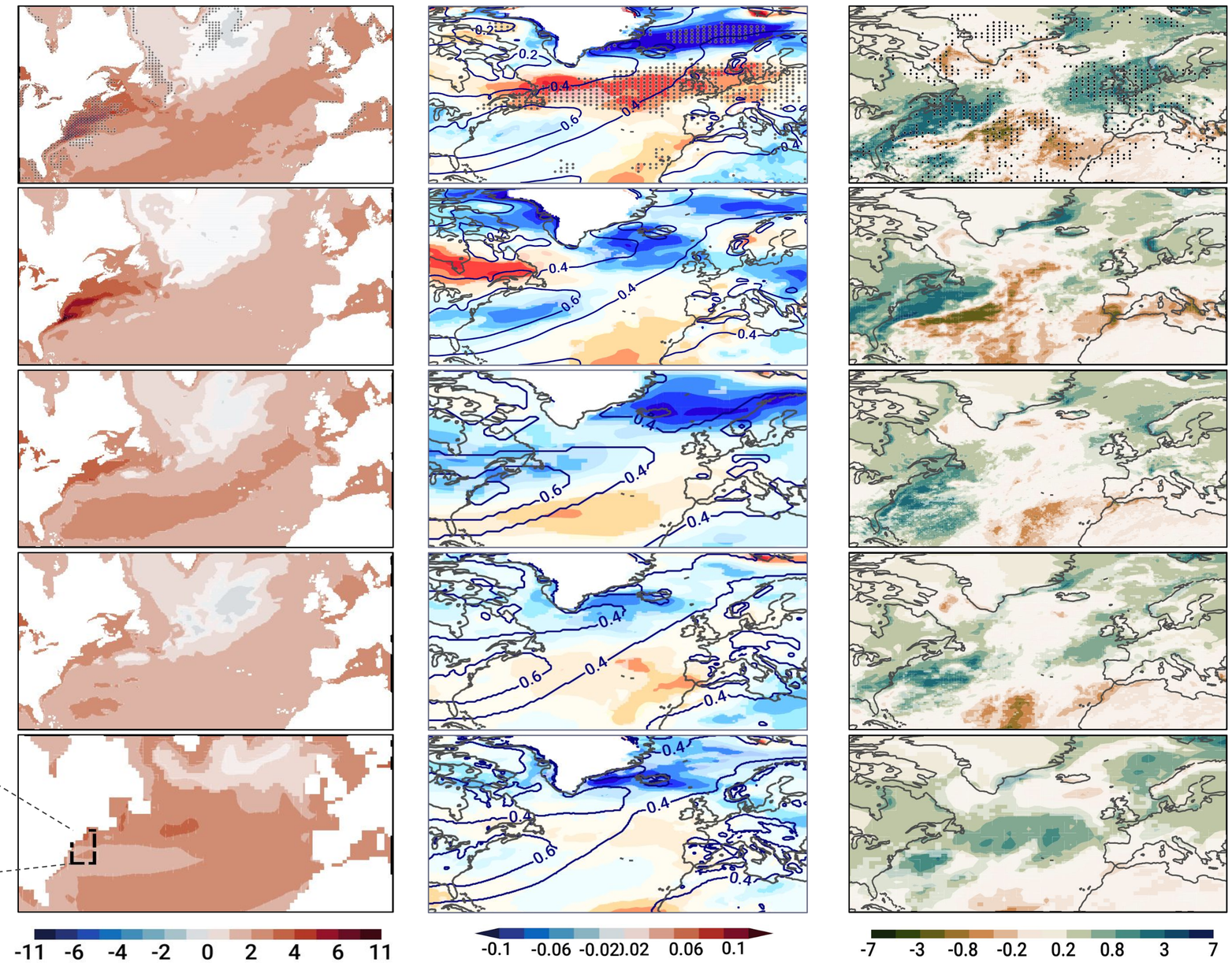
MM
~100 km atmosphere
~25 km ocean
3 historical simulations
3 SSP5-8.5 scenarios

LL
~250 km atmosphere
~100 km ocean
8 historical simulations
4 SSP5-8.5 scenarios

Sea-surface height meridional gradient in the Gulf Stream over time (10^{-6} m/m)



2030–2050 vs 1960–1980 change in SST (K, left), DJF max. Eady growth rate (d^{-1}, center), and DJF precipitation (mm/d, right)



The eddy-rich EC-Earth global model: first results of the HighResMIP historical simulation

EC-Earth model resolutions:

- VHR: Very-high resolution
  IFS T1279–ORCA12
  ~15 km atmosphere, ~8 km ocean
- HR: High resolution
  IFS T511–ORCA025
  ~40 km atmosphere, ~25 km ocean
- SR: Standard resolution
  IFS T255–ORCA1
  ~80 km atmosphere, ~100 km ocean

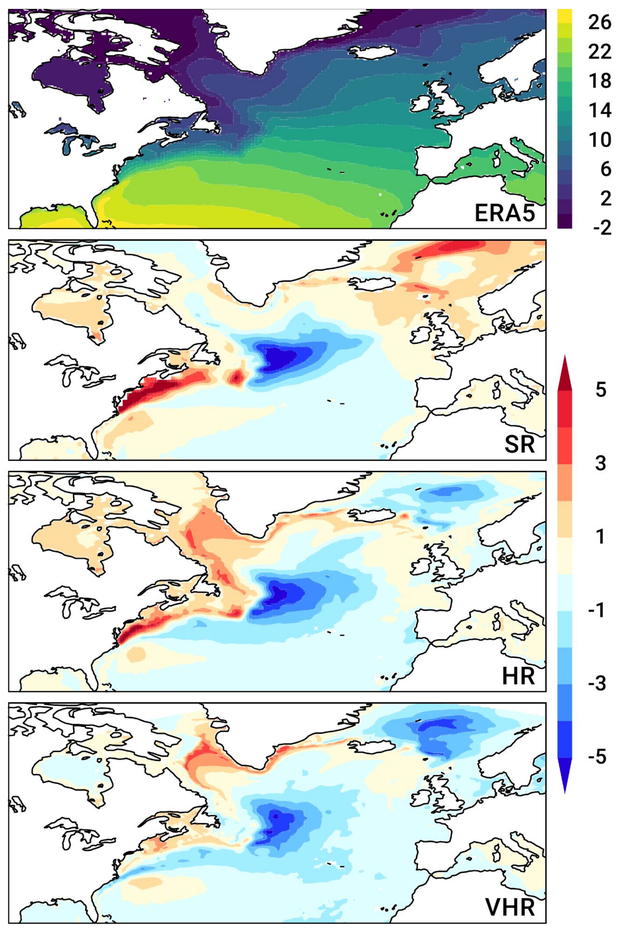
VHR HighResMIP experiments

- hist-1950 (1950–2014): complete
- future-highres (2014–2050): ongoing
- 1950-control: ongoing (~65 years)

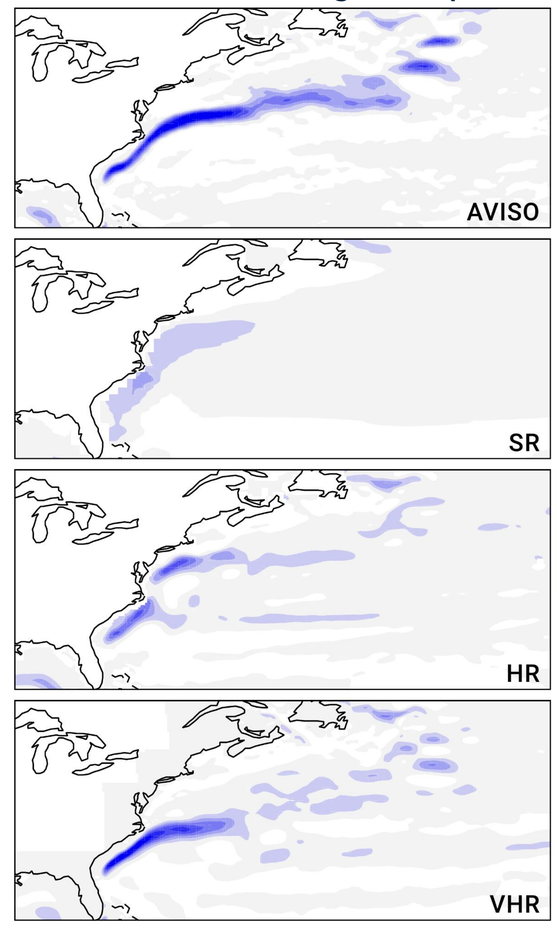
Future plans

- Verify the Gulf Stream warming–European precipitation increase mechanism in EC-Earth-VHR
- Investigate the influence of the ocean mesoscale on the meridional and gyre Atlantic circulation in various eddy-rich models (e.g., EC-Earth, HadGEM3, MPI-ESM, CESM)

1980–2014 SST bias (K; left) and monthly SST–surface energy flux correlation (right)



1993–2014 SSH meridional gradient (10^{-6} m/m)



Scan, and share

For the flight back: Moreno-Chamarro et al. (2021)